ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY

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EVALUATION OF COMPOSITE SLAB FOR LOW COST HOUSING IN ADDIS ABABA

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CIVIL ENGINEERING.

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Declaration

I, the undersigned, declare that this thesis is my Original work and all sources of materials used for the thesis have been duly acknowledged.

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Last but not least, I express my deep appreciation and gratitude to the staffs of Civil Engineering Department for their kindly support in the course of the study.

List of notations

A_c Area of concrete per unit width

A_p Gross Area of profile steed per unit with

A_{p2} Area of profile steed deck for lower part from center to center width

A_{SR} Area of transverse reinforcement steed

a_p punching load dimension

b the mean width of dock

b_t unit width of slab

b_c the effective width of slab

b_o the mean width of dock grove

C_p critical perimeter for punching

d the depth of Ribbed slab

d_R The depth of longitudinal reinforcement

d_p effective depth of composite slab

E_{cm} second modules of elasticity of concrete

Es modulus of elasticity of steel

Ea Modulus of elasticity of decking

f_{ctd} the design tensile strength of concrete

f_{ctk} the characteristic cylinder tensile strength of concrete

f_{sk} the characteristic cylinder tensile strength of transverse Reinforcement bar

f_{cd} the design compressive straight of concrete

f_{yp} Guaranteed minimum yield strength

h_f the thicknesses of floor finish

h_c the thickness of concrete for composite slab

I_{cm} second moments of area of the unreinforced composite slab

I_{uc} untracked second moment of area

I_{cc} cracked second moment of area

I_i second moment of area for Ribbed slab

I_p second moment of area for profile sheet

$\mathbf{i}_{Rd}$ the basic shear strength

L span length

Lp the length of mead point from one end

Ls one fourth of the span

M_{Rd} Design moment resistance of concrete

Msd design moment

M_k The maximum applied moment at mid span due to sustained characteristic loads

Mcr cracking moment of the section

Mpa plastic resistant moment capacity of profiled sheet

M_{pRd} Design moment resistance of profile sheeting

n modular ratio

Q_k Variable load

Q_{sd} design point load

t_p thickness of profile sheeting

V_{sd} Design shear

V_c shear resistance by concrete

V_{pa} characteristic resistance to vertical shear

V_{Rd} Design resistance of vertical shear

W unit Action

X The depth of the stress block

Z moment Arm

r reinforcement ration

g_{vs} safety factor for longitudinal shear

g_{ap} safety factor for flexor

s_i the deflection due to the theoretical cracking moment m_{cr} acting on the uncracked transformed section

s_{ii} the deflection due to the balance of the applied moment over and above the cracking value and acting on a section with on equivalent stiffness of 75% of the cracked value s_{max} the deflection of fully cracked section

List of abbreviation

DD = Design dead Load

DL =Design Live Load

EBCS= Ethiopian Building Code Standard

Kg = Kilogram

L = Span length of a beam

Millimeter

NAP = Position of Neutral axis

PNA =Plastic Neutral Axis

RC =Reinforced Concrete Structure

RCF =Reinforced concrete frame

S = Spacing of reinforcing bar

t_p = thickness of profile decking

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Abstract

This paper investigates the economical advantage of composite slab over pre cast beam slab. The structural design was done by SAP software and the cost analysis was calculated. nine different models were taken by varying column spacing for each of the cases. The comparison was done on G+2 building . This paper doesn't consider height of building.

The result of the research showed that ribbed slab structure has lesser cost up to 7m column spacing . For column spacing greater than 7m composite slab has lesser cost.

CHAPTER ONE

1. Introduction

1.1 Background

Housing is one of the basic human needs next to food & clothing. However fulfilling this basic need becomes so difficult in the developing countries because building cost of houses is highly rising to the extent of which could not be afforded by low class citizens. This is also true areas like Addis Ababa

Thus, providing low cost houses for such citizens is vital, by providing different construction methodology such as composite slabs and pre cast beam slab, which can reduce the time taken to construct and the cost of other inputs such as material and labor.

Appropriate cost-effective technology should make most effective use of available resources and result in the maximum overall benefits to the society at minimum costs. Cost-efficiency is one of the most crucial points of low-cost housing. It can mainly be achieved by standardization of building elements and reducing the number of different items needed. Prefabrication
and the use of special tools to produce these standardized elements maximize productivity, resulting in lower cost per unit.
Through intelligent dual-usage of building elements as building part and as formwork the construction costs are reduced. In the construction process, the amount of wasted materials for formwork can be reduced as well the time for building and dismantling formwork.

Composite construction is particularly competitive for medium or long span structures where a concrete slab or deck is needed for other reasons, where there is a premium on rapid construction, and where a low or medium level of fire protection to steelwork is sufficient (R. P. Johnson 1994)

1.2 Objective

1.2.1 General objectives

- To evaluate the economic advantage of composite slab over ribbed slab for low cost houses.

1.2.2 Specific objectives

- To indicate the extent of composite slab economical advantage to that of ribbed slab.
- To determine economical column spacing for composite slab to that of ribbed slab.

1.3 Significance research

The result of the research could be used for low cost housing construction in order to decrease the cost of the house without losing structural capacity of the building.

1.4 Scope

The scope of the study has been limited structural analysis for composite and ribbed slab with different column spacing and Cost Analysis conducting for the two slab cause than comparison was made

1.5 The study design and methodology

The research will make about building structure specially floor slab, which begins with conceptual literature study and internet serving to develop structure suitable data collection mechanism. The literature also acquired the primary as well as secondary data . The general methodology following throughout the research in the following diagram.

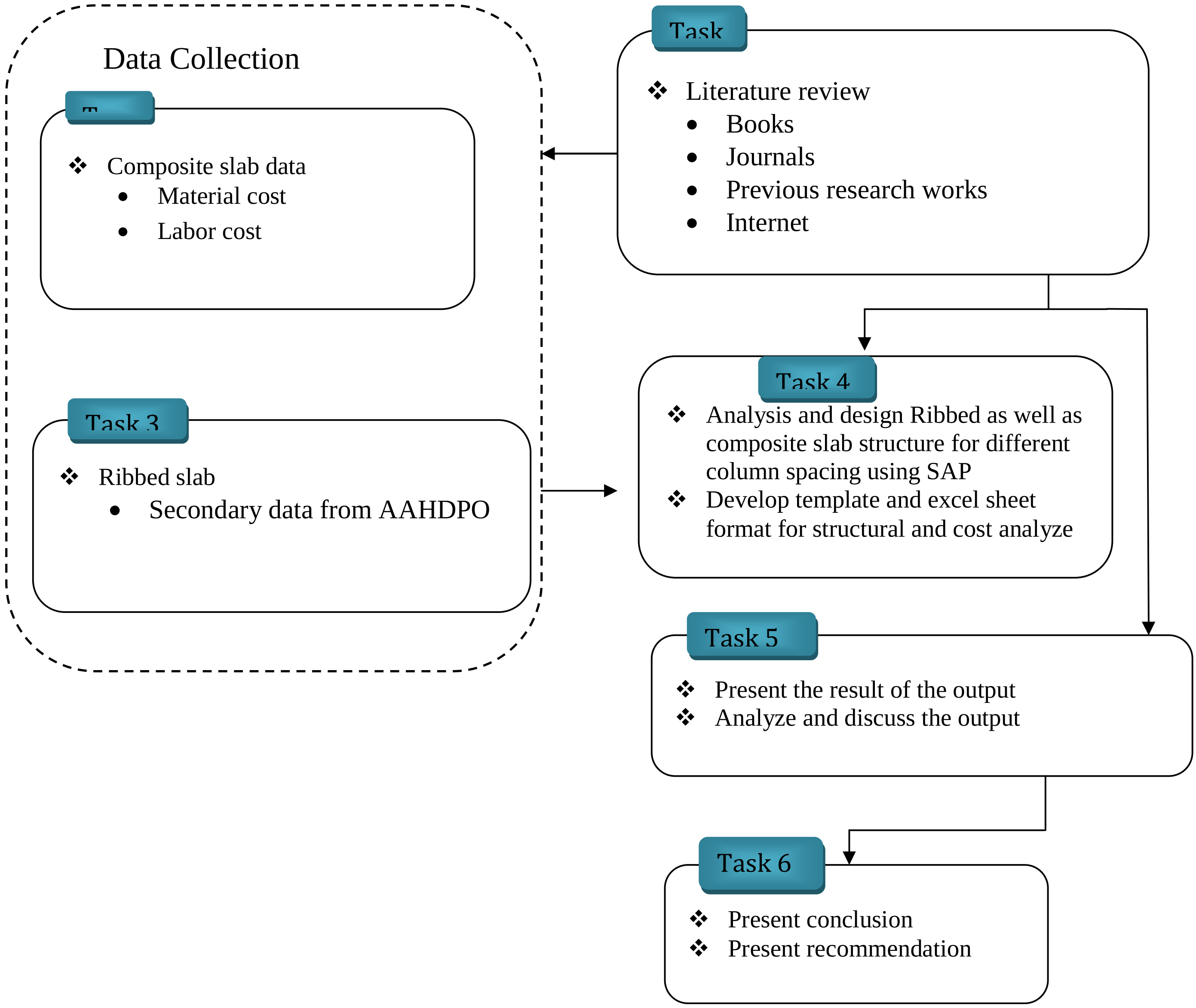


Fig 1.3 Visualization of the thesis progress steps

1.6 Organization of the thesis

This thesis contains five chapters. Chapter one introduction under is genera, Objective of the research, significance, scope of thesis, the stud design and methodology and Organization of the thesis were include

Chapter two discusses literature review stated about Economical advantages of pomposity and ribbed slab

Chapter three focus on Analysis and design consideration and design example of composite and ribbed slab

Chapter four discusses about output of analysis and design

chapter fire describe about conclusion and recommendation of the thesis with relate other finding

CHAPTER TWO

2.Literature Review

The concept of composite structures of steel and concrete, like composite slabs, beam and column discusses using composite structure of steel and concrete will save construction time of building, this loss of income from capital may be 10% of the total cost of the building ; that is, about one third of the cost of the structure. The construction time is strongly influenced by the time taken to construct a typical floor of the building.

Even more time can be saved if the floor slabs are cast on permanent steel formwork that acts first as a working as a working platform, and then as bottom reinforcement for the slab. This formwork, known as profiled steel sheeting , has long been used in most regions where the sheeting is readily available, such as Europe, Australasia and Japan. These floors span in one direction only, and are known as composite slabs. where the steel sheet is flat, so that two-way spanning occurs, the structure is known as a composite plate.

Buildings of composite slab decking can be positioned on the structure by crane and the individual sheets then installed by hand. Using this process, crane time is minimal, and in excess of 400 m^2 of decking can be installed by one team in a day, depending on the shape and size of the building footprint. The use of the decking as a working platform speed the construction process.(R.P. Johnson 1994)

Composite construction is considerably stiffer and stronger than many other floor systems. So the weight and size of the primary structure can be reduced consequently, foundation size can be reduced. (SCI No p300)

One of the primary concerns of cost-in-place system is they usually require the use of formwork and shoring while curing, which results in increases in construction and duration over typical composite construction.(Nathan jondewit, M.S.C. 2012)

The only way to maximize production of housing would be making optimum use of the available resources and stretch them to the maximum extent possible, through adoption of a technology appropriate to the present circumstances.

Appropriate cost effective technology should make most effective use of available resources and result in the maximum overall benefits to the society at minimum cost. Cost efficiency is one of the most crucial points of low cost housing. It can mainly be achieved by standardization of building elements and reducing the number of different items needed. Prefabrication and the use of special tools to produce this standardized element maximize productivity, resulting in lower cost per unit. (Matheas Kebede, M.S.C 2009)

Economical advance using profaned deck is achieved due to speed in construction. They notified normally 2.5 to 4m spans can be handed without propping (sijaria et al. 2014)

Composite structural system because of the lesser magnitude of the bean and forces and moments compared to an R.C system one can use lighter section in a composite stricter thus, it reduces the self weight an cost of the structural components. This downward reaction and bending moment in other two directions for composite structural system is less . under earthquake consideration because of inherent ductility perform better that a RC structure (shweta A. Et al 2014)

Performed structural analysis and design for steel-concrete composite frames and stated that short to medium span (6m to 12m) composite floor beams perform quite well and are rarely found to transmit annoying vibrations to the occupants and particular care is required for long span beam more than 12m. They also stated that steel-concrete composite beams are highly efficient and economic with bay sizes in the range of 6m to 12m (Liew and Richard Jat Yuen 2001)

Economic advantage of fabricated beams that they can be designed to provide the required moment and shear resistance along the beam span in accordance with the loading pattern along the beam. They concluded that steel-concrete composite tapered beams are found to be economical for spans up to 20 m. **(**Brian Uy and J.Y. Richard Liew 2003)

building frames with column spacing between 9 to 10m and greater than this span along both axes, steel-concrete composite construction has economical advantages than reinforced concrete construction and 9 to 12 and greater than this storeys, again, steel-concrete composite construction has economical advantages than reinforced concrete construction in our country.(Bergene Bassa M.S.C 2016)

2.1. Composite and pre cast beam slab

a) Composite slab

Composite slab consists of a profiled steel sheet which is dimple at the surface and an upper concrete topping which are interconnected in such a manner that horizontal shear force can be transferred at the steel concrete interface

Typical example of composite slab construction is shown in figure below

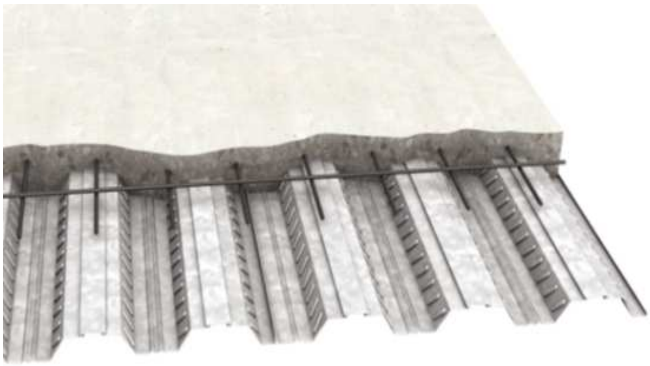


Fig 1.1 section of composite slab

Advantages and disadvantages of composite slab

The advantages of composite slab

- Simplicity of construction.
- Acts as stay-in-place formwork and offers an immediate working platform.
- Lighter construction than a traditional concrete building.
- Less on site construction.
- Acts as slab reinforcement.
- Ease of transportations and installation.
- Street tolerances achieved by using steel member's manufacturers under controlled factory condition to established quality procedures.

- greater resistance with less weight.
- cost redaction; both in terms of labour costs and prices, as there is no need for props, and in terms of material, as less concrete is used, which in turn means a lighter structure and less waste

Some of the disadvantages are

- High cost of materials the necessary fire protection system.
- Not available of material locally.
- Prior to concreting, the steel deck panels must be clean from dirt, debris, oil and foreign matter.

b) Pre-cost beam slab

Pre-cost beam slob is made of pre-cost reinforced concrete beam together with hollow concrete blocks are laid between supports and used as permanent formwork for an in-situ concrete topping.

Slab depths typically vary from 75 to 125mm. and rib widths from 125 to200mm. Rib spacing of 600 to 1500mm can be used. The overall depth of the floor typically varies from 300 to 600 mm with overall spans of up to 15m if reinforced, longer post tensioned. The use of ribs to the soffit of the slab reduces the quantity of concrete and reinforcement and also the weight of the floor. the saving of materials will be offset by the complication in formwork and placing of reinforcement. however, formwork complication is minimized by use of standard, modular, reusable formwork, usually made from polypropylene or fiberglass and with tapered sides to allow stripping or lead hollow block between the rib (tps:civilgital.com)

Typical examples of pre-cost beam slob shown in figure below

Fig 1.2 pre-cast slab construction

Advantages and disadvantages of pre-cost beam slab

Advantages of pre-cost beam slab

- Simplicity in construction
- Used as temporary formwork
- Act as fire and sound proof
- Light weight
- Attractive soffit appearance if exposed
- Economical used as formwork

Disadvantages of pre-cost beam slab

- Concrete casting is not workable as composite slab
- It is not strong enough to use all type of building

CHAPTER THREE

3. Analysis and design

The analysis was done for two cases, for the composite slab and ribbed slab, without changing reinforced concrete frame structure for both cases. For each case nine G+2 buildings having the same floor plan has been taken. The nine buildings that are used in the analysis are got by varying the column spacing with 0.5m starting from 4m up to 8m. The connection detail for composite slab with RC beam section is shown in the fig 3.1.

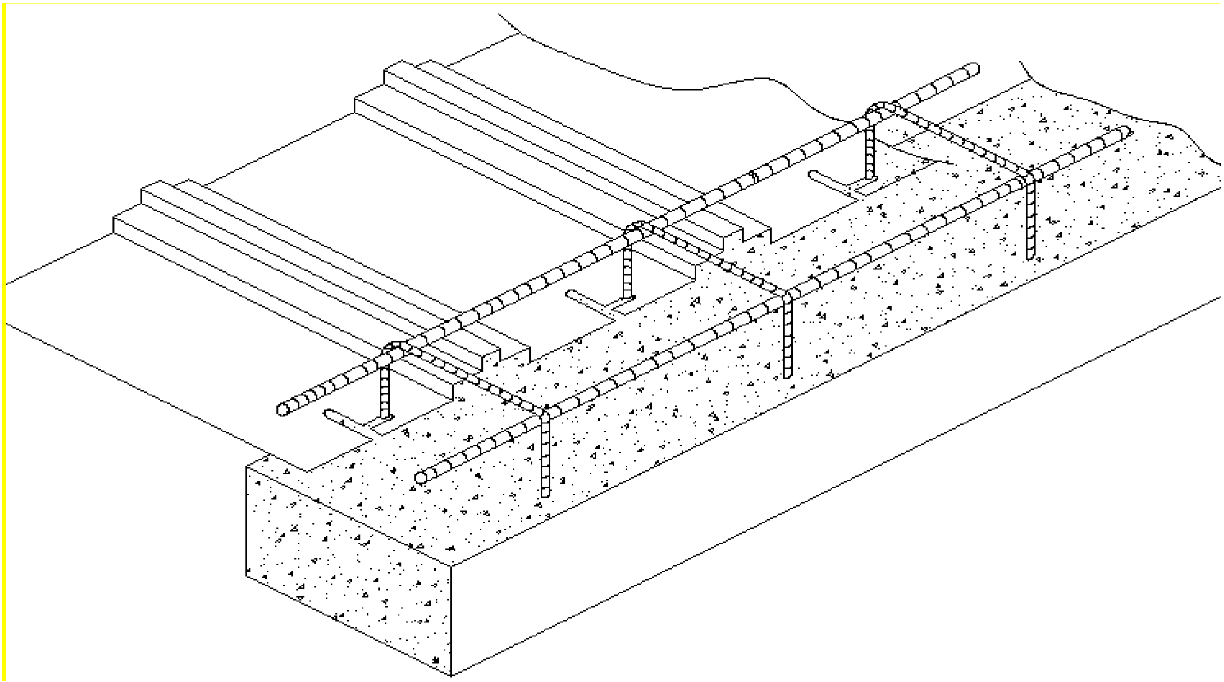


Fig 3.1 connection detail for composite slab with RC frame beam

3.1. Analysis and design of ribbed and composite slab

Sample design of ribbed and composite slab with building dimension of 10m width by 24m length and with 4m spacing have showed for other span design templates have prepared see on annex

Analysis of frame structure was conducted using SAP version 18 as an input of earthquake zone two and sub soil class B. Analysis and design attach on annex

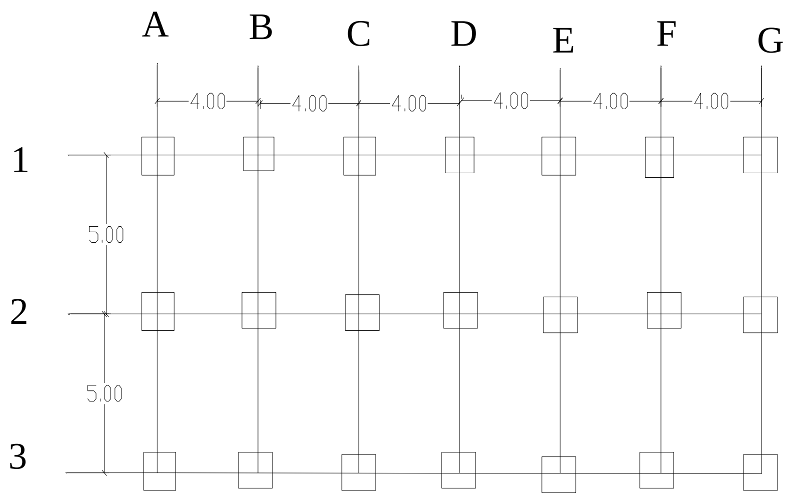


Fig. 3.2 typical floor plan

3.1. Analysis and design of ribbed slab

3.1.1. Load at different stages on pre-cast beam slab

Stag 1

At placing of pre-cast beam

Dead load

Weight of pre-cast element = 0.08 x 0.12 x 25 = 0.24kg/m^2

Stag 2

At block laying

Dead load

Weight of pre-cast element = 0.24kN/m^2

Weight of concrete hollow block = 1.64 x 0.04 x 12 = 0.787kN/m^2

Total = 1.16kN/m^2

Live load

The live load to be considered at this stage is the weight of block layer which is assumed to be 80kg person

J_{ob} = 80 x 10/1000 = 0.8kN

The load is applied at mid span to create the maximum deflection

Stag 3

When concrete casting

Dead load

Weight of pre-cast element = 0.24kN/m^2

Weight of concrete hollow block = 0.787kN/m^2

Weight of fresh concrete =((0.08 x 0.1) +1/2 x 0.03 x (0.08+0.24) + 0.6 x 0.06) x 25

=1.22kN/m^2

Total = 2.25kN/m^2

Live load

The live load to be considered at this stage is the weight of one mason and one daily labor, who support the mason.

Stag 4

Operation stage

Dead load

Weight of pre-cast element = 0.24 kN/m^2

Weight of concrete hollow block = 0.787 kN/m^2

Weight of dry concrete = 1.22 kN/m^2

Floor finish terrazzo = 23 x 0.02 x 0.6 = 0.28 kN/m^2

Ceiling plastering = 23 x 0.02 x 0.6 = 0.28 kN/m^2

Partition load = 1.8KN/m^2 x 0.6 = 1.2 kN/m^2

Total = 4.0 kN/m^2

Live load

Qj = 2 KN/m^2 for domestic and residential activities

= 2 x 0.6

= 1.2 KN/m^2

3.1.2 Materials selection

2.1.2.1 Concrete C_{25}

$$f_{cd} = \frac{0.85 \text{ x } f_{ck}}{\gamma_c} = \frac{0.85 \text{ x}20}{1.5} = 11.33$$

$$f_{ctd} = \frac{f_{ctk}}{\gamma_c} = \frac{1.5}{1.5^-} = 1.0\text{Mpa}$$

E_{cm} = 29Gpa

2.1.2.2 Steel

The design strength of steel in tension and compression is given by

$$f_{cd} = \frac{f_{yd}}{\gamma_c} = \frac{500}{1.15} = 434.78$$

E_s = 200Gpa

3.1.3 Load combination considered

COMBO1 = 1.3G +1.6Q……….. For ultimate limit state

COMBO2 = G+Q………………. For serviceability limit

3.1.4 Design example for per-cast beam slab having 4m span length

The cross-section to be analyzed

Assuming 2 Ø12 reinforcement for tension and 1 Ø10 for compression

B = 120mm   H = 260mm

d = 55mm   h = 180mm

A_s = 226.19mm $A_{s'}$ = 78.5mm

<u>At stag 1</u>

At placing of pre-cast beam

G = 0.24kN& Q = 0

h = 28cm

d = h-2.5cm = 25.5cm

b = 12cm

$w_d = 1.3 \text{ x } G + 1.6 \text{ x } Q$

$w_d = 1.3 \text{ x } 0.24 = 0.312$

$M = \frac{w \text{ x } L^2}{8} = \frac{0.312 \text{ x } 4^2}{8} = 0.624\text{kN-m}$

Nominal strength, $M_{n,exp}$ can be found experimentally

$$M_n, \exp = M_{n,cb} + \Delta M$$

Where $M_{n,}\exp$ is experimental nominal strength

$M_{n,\,cb}$ is moment resist by concrete block

ΔM is moment resist above concrete block

$M_n, \exp = \frac{(\frac{p}{2})L}{3}$ but $p = w_d \text{ x } L = 0.312 \text{ x } 4 = 1.248$

$= \frac{\left(\frac{1.248}{2}\right) \text{ x } 4}{3} = 0.832$………………ok

But check for compression and buckling resistance of top reinforcement

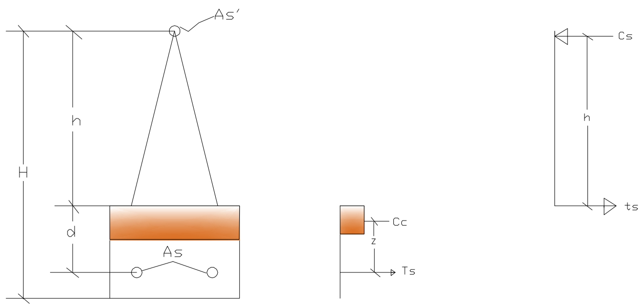


Fig 3.3 model of precast section

$f_s = \xi_s E_s$

$\xi_s = \xi_{cm} \frac{d-x}{x}$ by similarity of triangle

$C_c = T_s$ or $0.8x \text{ x } b \text{ x } f_{ck} = A_s f_s$ by equilibrium of force

$0.8x\text{x}b\text{x}f_{ck} = A_s \text{ x } [e_{cu} \text{ x } E_s \frac{(d-x)}{x}]$

From the equation x can solved then by similarity of triangle can get the value of $\xi_{s,}$ which able to compeer with ξ_y of steel, to know whether the failure do to compression of concrete or tension of steel.

The ultimate moment of the precast block that failure can occurs, may be found

$M_{n,cb} = C_c \text{ x } Z$ or

$M_{n,cb} = T_s \text{ x } Z$

$\Delta M = M_n, \exp - M_{n,cb}$

$\Delta M = C_s \text{ x } h$

$= t_s \text{ x } h$

$C_s = \Delta M/h$

Now using the value of C_s should be checked against compression and Bulking resistance

$0.8x \text{ x } b \text{ x } f_{ck} = A_s \text{ x } (e_{cu} \frac{E_s\,(d-x)}{x})$

$0.8x^2 \text{ x}120\text{x}20 = 226.2 \text{ x } (0.0035\text{x}200000\text{x}(55-x))$ by quadratic equation

$x = \underline{37.73}$ using similarity of triangles

$\xi_s = \frac{17.26 \text{ x } 0.0035}{37.73} = 0.0016 < 0.0017 = \varepsilon_y$

$C_c = 0.8 \text{ x } C \text{ x } b \text{ x } f_{ck}$

= 0.8 x 37.73 x 120 x 20

= 72.44kN

Z = d-0.4c

= 60-0.4x37.73

= 44.91mm

$M_{n,cb}$ = C_c x Z

= 72.44x0.045

= 3.26kN-m

ΔM = M_n, exp- $M_{n,cb}$

= 0.832kN-m - 3.26kN-m = -2.43

Negative sign shows that applied action very much lesser the capacity of pre-cast concrete. there for no need to check upper reinforcement against compression and buckling resistance.

At stage 2 and 3 the pre-cast beam supported two places at middle by props, the span length became short, so no need a calculation

<u>At stage 4</u>

Operational stage

Reinforcement require for flexural

Load combination

$W = 1.3\, G + 1.6Q$

=1.3 x 4.0+1.6 x 1.2

= 7.12

$^{M}\text{max} = \frac{w_d \text{ x } L^2}{8} = \frac{7.12 \text{ x } 4^2}{8} = 14.24$

d = 300- 25 – 5 = 270mm or 0.27m

$^{K}\text{m} = \frac{\sqrt{M_{mex/b}}}{d} = \frac{\sqrt{14.24/0.12}}{0.27} = 40.34 \approx 40$

Ks = 2.72

$\text{Ast} = \frac{K_s M}{d} = \frac{2.72*13.72}{0.27} = 138.216$

Use 2Ø 10 (157.08mm^2) bottom reinforcement

2Ø 10 reinforcements are just sufficient for the span of 4m check for shear

Maximum shear force Vsd = $\frac{7.12*4}{2}$ = 14.24 (KN)

Concrete shear resistance

$Vc = 0.25$ fad K_1 K_2 $b_w d$

Where $K_1 = 1+50p = 1+50 \text{ x } \left(\frac{157.1}{0.27*0.12}\right) = 1.242$

$K_2 = 1.6\text{-}d = 1.6 - 0.27 = 1.33$

$Vc = 0.25x10^3x1.242 \text{ x}1.33x0.12x0.27=13.384$

$Vc < Vsd$

There for sear reinforcement is required

When inclined stirrups are used the shear resistance of the stirrups may be calculated as:

$$Vs = \frac{A_v d\, f_{yd}\,(\text{Sinx} + \text{cosx})}{S}$$

By using S300 diameter 6 bars

$Av = 2x\,\frac{\pi 6^2}{4} = 56.55mm^2$ $d = 27$ $f_{yd} = 260.87$ $X= 51.34$

$$Vs = \frac{56.55*27*260.87\ (\sin 51.34+\cos 51.34)}{20}$$

Vs = 27,992.42 = 27 .99 KN/mm2 >Vsd (14.24) … ok

Serviceability requirement of working stage

Deflection at working stage

$$S_i = \frac{5}{48}\,L^2\,\frac{M_{cr}}{EcmI_i}$$

$$S_{ii} = \frac{5^{22}}{48}\,\frac{mk - m_{cr}}{0.75E_C A_S 2\ (d-x)}$$

$Mcr = 1.7\ f_{ctk}Z$

for $K_x = 0.224$ x= 0.06

For Kz = 0.908 Z = 0.245

$$Ii = \frac{600*60^3}{3} + \frac{120*240^3}{3} + 5.9x\ 157.1 \text{ x } 220^2$$

$Ii = 764.1x107\ mm^4 = 641 \text{ x } 10^6mm4$

$$Z= \frac{641x10^6m^4}{240m} = 2.67x10^6\ mm^3$$

Mcr = 1.7x1.5x2.67= 6.811 (kN-m)

$$S_{max} = \frac{5}{48} \text{ x } 4000^2\ \frac{14.24 \text{ x } 10^6}{(0.75 \text{ x } 200000 \text{ x } 157.08 \text{ x } 0.245 \text{ x } 10^3 (120-60))}$$

$S_{max} = 65.14mm$

S_i = 5/48 x $4000^2 \frac{6.811 \times 10^6}{29000 \times 641 \times 10^6}$ = 0.611mm

S_{ii} = 5/48 x $4000^2 \frac{(14.24-6.811) \times 10^6}{(0.75 \times 2 \times 10^5 \times 157.08 \times 245 \times (120-60))}$

S_{ii} = 33.98

$S_i + S_{ii}$ = 34.59 < 66.51 …. Ok

3.2 Design for composite slab having 4 m span length

Table 3.1 Structural properties of profile sheeting

Nominal thickness (mm)	Design thickness (mm)	profile weight (KN/m^2)	Area of steel (mm^2/m)	Height of neutral ONS (mm)	Moment of inertia (cm^4/m)
0.9	0.86	0.10	1178	30.34	54.80
1.00	0.96	0.11	1313	30.33	61.80
1.10	1.06	0.12	1445	30.33	68.80
1.20	1.16	0.13	1578	30.32	76.00

Assume using 0.9 thick profile sheet

Yield strength f_{yp} = 280 N/mm^2

Design thickness t_p = 0.86mm

Effective area A_p = 1178mm^2/m

Second moment of Area I_p= 0.548mm^4/m

Characteristic plastic

Moment of resistance M_{pa} = 4.92 KNm/m

Distance of centroid above base e = 30mm

Distance of plastic neutral axis

Above base e_p = 30.34 mm

Characteristic resistance to

Vertical shear V_{pa} = 49.2 KN/m

For resistance to longitudinal shear M = 189 N/mm^2

K = 0.08 N/mm^2

$J_{u.Rd}$ = 0.23N/mm^2

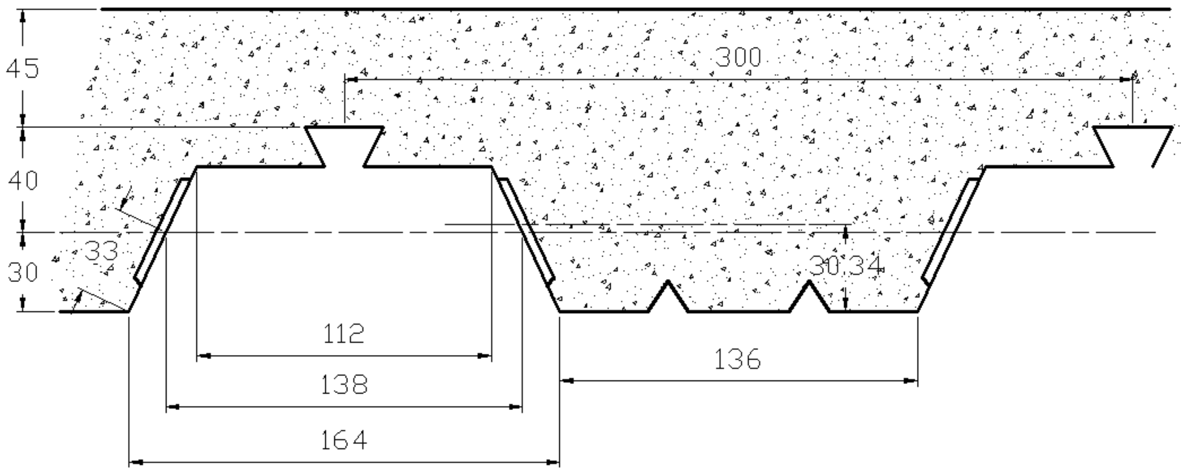


Fig 3.4 section of profile steel sheeting

3.2.2 profiled steel sheeting as shattering

Density of concrete (wet) = 2400 kg/m^3

(dry) = 2350kg/m^3

Dead load = (1.747 + 0.1) x 1.30 = 2.4 kN/m^2

Live load = two person having average weight of 70 kg

140 x10m/s^2 = 1400 N/m^2 = 1.4kN/m^2

Load combination = 1.3 q_k + 1.6Qk

= 2.40 + 2.44 = 4.64kN/m^2

Assume the width of the beam is 20cm and prop is provide at the middle of the span, so the affective length of the spans is

$$Le = \frac{4000-200-70}{2} = \frac{3730}{2} = 1865\text{mm}$$

<u>Flexural and vertical shear</u>

The maximum design bending moments are

Sagging M_{sd} = 0.0959x 4.64 x 1.86^2 = 1.54 KNm/m

Hogging M_{sd} = 0.0625 x 4.64 x1.86^2 = 1.00 KNm/m

The design resistance is M_{Rd} =4.92/1.1 = 4.47 kNm/m …. Ok

<u>Vertical shear</u>

V_{sd} = 0.56 x 4.64x1.87 = 4.8 kN/m

V_{Rd} = Vpa/f $= \frac{49.2}{1.1}$ = 44.7 kN/m ….. ok

Serviceability

The maximum deflection δ max $= \frac{WL^4}{185EI_p}$

$$\delta \text{ max} = \frac{4.64 \text{ x } 1.86^4}{185 \text{ x } 0.21 \text{ x } 0.548}$$

δ max = 2.61

But the $\frac{\delta}{L}$ is lower the 1/250........ ok

3.2.3 Composite slab

Flexure and vertical shear

- Dead load

  Assume the total slab depth is 115 mm

  b, using Com Flor 70 the depth of sheeting is 70 mm so average depth of concrete we be 45+27.5 = 72.5mm

  - Wight of concrete = 1.7 kg/m^2
  - weight of profile = 0.1 kN/m^2
  - weight of flooring = 0.28 kN/m^2
  - weight of partition = 1.2 kN/m^2

    Total = 3.28 kN/m^2

live load

- for domestic and residential activities Qk 2kN/m^2

load combination considered

COMBOl = 1.3G+6Q = 1.3 x3.28 +1.6x2 = 7.464 kN/m^2

moment on the a unit width of slab is

$$\text{Msd} = \frac{WL^2}{8} = \frac{7.464 \text{ x } 3.87^2}{8} = 13.96 \text{ kN m/m}$$

bending resistance

$$N_{cf} = \text{Ap x} \frac{f_{yp}}{\delta} = 1178 \text{ x} \frac{0.28}{1.1} = 299.85$$

$$X = \frac{Ncf}{fcd} = \frac{299.85}{11.33} = 26.47\text{mm}$$

his is less tan thickness of concrete

The depth of composite slab is 115-30.34 = 84.66

$Mp._{Rd}$ = Ncf (dp$\frac{x}{2}$)

= 299 .85 x (84.66 -$\frac{26.47}{2}$) = 21 .42 kN m/m ….ok

Vertical shear resistance

$$Vsd = \frac{WL}{2} = \frac{7.46 \text{ x } 3.87}{2} = 14.43$$

As shown in the figure

bo= 138mm b= 300mm dp = 84.66mm

the area A_{p2} = 0.86 x 136 = 116.97 = 117

$$P = \frac{AP}{bo*dp} = \frac{117}{1.38 \text{ x } 84.66} = 0.01$$

Kv = 1.6 – dp = 1.6 - $\frac{84.66}{1000}$ = 1.52

$$j_{Rd} = \frac{0.25 \text{ fctk}}{fc} = 0.25\text{x}\frac{1.5}{1.5} = 0.25$$

$V_{v \cdot Rd}$ = $\frac{138}{300}$ x 84.66x0.25x1.52x (1.2+40p) = 23.61 kN/m….. ok

Longitudinal shear

Longitudinal shear is checked by both the 'm-k' and partial interaction for case 'm-k' method is used.

Where b = 1000 mm m=184 N/mm^2

Dp= 84.66mm k= 0.053 N/mm^2

Ap = 1178 mm^2/m fvs = 1.25

$$V_{lRd} = bdp \left[\frac{mAP}{\frac{bLs}{fvs}} + k \right] = 18.76…..ok$$

Local effects of point load and punching shear

point load (Qsd) = 2x1.6 = 3.2 on any area 50mm^2

2kN Imposed loads is used for category A in EBC 51

Assume that thickness of floor finish is 50 mm then the data are

Bp= Qp = 50mm, hf = 50mm, h_c = 60 mm dp = 84.66

And T_{Rd} = 0.25 N/mm^2, kv = 1.52m, p = 0.01

There for punching shear

$$C_p = 2\pi h_c + 2(2d_p + \alpha p - 2h_c) + 2b_p + 8h_f = 2936.80 \text{ mm}$$

$$V_{p.Rd} = c_p h_c \tau_{Rd} K_v (1.2+40p) = 106.84 \text{…. ok}$$

Local bending

the load distribution width (bm&am) width wise and span wise respectively

$$a_m = b_m = a_p + 2(h_f + h_c) = 520.00$$

The most adverse situation for local sagging bending is when the load is at mid span, so Lp is 1.93m

There for the width of slab (be) is

$$be = bm + 2Lp\left[1 - \frac{Lp}{L}\right] = 2.45$$

The sagging moment per unit width is

$$Msd = Qd\ Lp\,\frac{1 - Lp/L}{be} = 0.95 \text{ kN m/m ….. ok}$$

Which is below the resistance of the slab 21.42 kNm/m

Transverse sagging moment

The transverse sagging moment is given by equation

$$Msd = Qd\,\frac{be - bm}{8} = 3.2 \times \left(\frac{2.45-0.52}{8}\right) = 0.58 \text{ kN m}$$

The moment per unit width is

$$Msd = \frac{0.58}{0.52} = 1.12$$

The depth of Reinforcement $d_R = 45 - 6/2 = 42$

The force At yielding $F_y = \frac{141.37 * 0.5}{1.15} = 61.46$

The depth of the concrete stress block is

$$X = \frac{N_{ef}}{f_{cd}} = 5.42$$

The lever arm (2) = $d_R - \frac{x}{2} = 54.29$

Transverse sagging moment resistance

$$M_Rd = 61.46 \times 0.0543 = 3.34 \text{ kNm/m ….. Ok}$$

Serviceability

If the span to depth ration is less than 32 no need of to calculate the deflection because the deflection is not excessive

Span/ dp = $\frac{3870}{84.66}$ = 45.71 so some calculation is need

Un cracked second moment of area (I_{cu}) is

$$I_{cu} = \frac{bhc^3}{12n} + \frac{bhc\,(xu - \frac{hc}{2})^2}{n} + \frac{bmhp^3}{12n} + \frac{bmhp}{n}\,(ht - x_u - \frac{hp}{2})^2 + Ap\,(dp - xu)^2 + I_p$$

Cracked second moment of area (Icc) is

$$Icc = \frac{bxc^3}{12n} + \frac{bxc^3}{12n} + \frac{bxc(\frac{xc}{2})^2}{n} + Ap\,(dp - x_c)^2 + Ip$$

The mean value of secant modulus (Ecm) of concrete for C_{25} is 29 (EBC 52)

The mean value of modular ration is $\frac{Es}{Ecm} = \frac{210}{29}$ = 7.24

I_{cu} = 15.2 x 106

Icc = 5.4x 106

The mean value of second moment of area (Im) is

$Im = \frac{15.2+5.4}{2} = 10.3 \ x10^6\ mm^4/m$

The mid span deflection (δ) is

$$\delta = \frac{WL^4}{185\ EIm} = \frac{9.4x\ 3.87^4}{185x0.2x10.3} = 5.54$$

Hence $\frac{\delta}{L} = \frac{5.54}{3870} < \frac{1}{250}$ …… ok

CHAPTER FOUR

4. Design output and Discussion

4.1 Design output

After analysis and design of slab and frame structure of ribbed and composite taken then cost comparison table are prepare for future references, which present manly the cost for different span length stetted as 4m, 4.5m, 5m, 5.5m, 6m, 6.5m, 7m, 7.5m and 8m.

During cost analysis the material and labor cost only considered without overhead and profit because mostly overhead and profit cost are different from firm to firm.

Table 4.1 Summary of cost output 4m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	16.90	30420.00
1.02	Column	m^3	1800.00	22.72	40896.00
1.03	Beam	m^3	1800.00	35.84	64512.00
1.04	Slab	m^2	400.00	446.88	178752.00
	Total summary				**314580.00**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	139.86	3496.50
2.02	b) Φ 8mm	Kg	25.00	1877.74	46943.58
2.03	c) Φ 10mm	Kg	25.00	655.00	16375.00
2.04	d) Φ 12mm	Kg	25.00	3834.51	95862.75
2.05	e) Φ 14mm	Kg	25.00	1698.40	42460.00
2.06	f) Φ 16mm	Kg	25.00		0.00
2.07	g) Φ 20mm	Kg	25.00	601.95	15048.70
	Total summary				**220186.53**
	Grand total				**534766.53**

Table 4.2 Summary of cost output 4.5m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	19.39	34906.50
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	37.89	68206.32
1.04	Slab	m^2	400.00	505.68	202272.00
	Total summary				**346289.37**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	179.82	4495.50
2.02	b) Φ 8mm	Kg	25.00	1927.73	48193.25
2.03	c) Φ 10mm	Kg	25.00	704.97	17624.25
2.04	d) Φ 12mm	Kg	25.00	4172.32	104308.00
2.05	e) Φ 14mm	Kg	25.00	1481.03	37025.75
2.06	f) Φ 16mm	Kg	25.00	579.49	14487.25
2.07	g) Φ 20mm	Kg	25.00	523.00	13075.00
	Total summary				**239209.00**
	Grand total				**585498.37**

Table 4.3 Summary of cost output 5m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	20.21	36375.30
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	39.94	71899.92
1.04	Slab	m^2	400.00	564.48	225792.00
	Total summary				**374971.77**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	191.81	4795.25
2.02	b) Φ 8mm	Kg	25.00	1982.69	49567.17
2.03	c) Φ 10mm	Kg	25.00	745.69	18642.25
2.04	d) Φ 12mm	Kg	25.00	4587.73	114693.25
2.05	e) Φ 14mm	Kg	25.00	1542.68	38567.00
2.06	f) Φ 16mm	Kg	25.00	498.65	12466.25
2.07	g) Φ 20mm	Kg	25.00	680.89	17022.25
	Total summary				**255753.42**
	Grand total				**630725.19**

Table 4.4 Summary of cost output 5.5m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	28.99	52179.75
1.02	Column	m^3	1800.00	23.64	42558.30
1.03	Beam	m^3	1800.00	47.10	84773.52
1.04	Slab	m^2	400.00	686.88	274752.00
	Total summary				**454263.57**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	225.91	5647.68
2.02	b) Φ 8mm	Kg	25.00	2261.30	56532.60
2.03	c) Φ 10mm	Kg	25.00	828.43	20710.84
2.04	d) Φ 12mm	Kg	25.00	4068.25	101706.19
2.05	e) Φ 14mm	Kg	25.00	1946.49	48662.25
2.06	f) Φ 16mm	Kg	25.00	1256.25	31406.31
2.07	g) Φ 20mm	Kg	25.00	550.14	13753.53
2.08	g) Φ 24mm	Kg	25.00	949.63	23740.63
	Total summary				**278419.39**
	Grand total				**732682.96**

Table 4.5 Summary of cost output 6m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	39.60	71282.70
1.02	Column	m^3	1800.00	25.78	46398.15
1.03	Beam	m^3	1800.00	53.61	96500.16
1.04	Slab	m^2	400.00	779.52	311808.00
	Total summary				**525989.01**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	215.78	5394.60
2.02	b) Φ 8mm	Kg	25.00	2240.85	56021.27
2.03	c) Φ 10mm	Kg	25.00	552.89	13822.34
2.04	d) Φ 12mm	Kg	25.00	1480.03	37000.74
2.05	e) Φ 14mm	Kg	25.00	5176.50	129412.57
2.06	f) Φ 16mm	Kg	25.00	1771.64	44290.95
2.07	g) Φ 20mm	Kg	25.00	269.40	6734.91
2.08	g) Φ 24mm	Kg	25.00	1767.90	44197.50
	Total summary				**292677.38**
	Grand total				**818666.39**

Table 4.6 Summary of cost output 6.5m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	49.61	89291.93
1.02	Column	m^3	1800.00	28.99	52178.40
1.03	Beam	m^3	1800.00	64.83	116689.68
1.04	Slab	m^2	400.00	922.32	368928.00
	Total summary				**627088.01**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	346.32	8658.00
2.02	b) Φ 8mm	Kg	25.00	2306.50	57662.50
2.03	c) Φ 10mm	Kg	25.00	611.08	15276.92
2.04	d) Φ 12mm	Kg	25.00	1545.39	38634.66
2.05	e) Φ 14mm	Kg	25.00	6832.54	170813.57
2.06	f) Φ 16mm	Kg	25.00	1711.00	42775.11
2.07	g) Φ 20mm	Kg	25.00	0.00	0.00
2.08	g) Φ 24mm	Kg	25.00	2385.25	59631.13
	Total summary				**333820.75**
	Grand total				**960908.76**

Table 4.7 Summary of cost output 7m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	61.33	110396.93
1.02	Column	m^3	1800.00	31.43	56572.65
1.03	Beam	m^3	1800.00	68.52	123342.48
1.04	Slab	m^2	400.00	1101.48	440592.00
	Total summary				**730904.06**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	410.26	10256.40
2.02	b) Φ 8mm	Kg	25.00	2986.84	74671.00
2.03	c) Φ 10mm	Kg	25.00	504.95	12623.82
2.04	d) Φ 12mm	Kg	25.00	1684.45	42111.18
2.05	e) Φ 14mm	Kg	25.00	5303.28	132581.96
2.06	f) Φ 16mm	Kg	25.00	6226.63	155665.72
2.07	g) Φ 20mm	Kg	25.00	216.11	5402.73
2.08	g) Φ 24mm	Kg	25.00	4321.59	108039.81
	Total summary				**433312.81**
	Grand total				**1164216.86**

Table 4.7 Summary of cost output 7.5m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m3	1800.00	78.44	141183.00
1.02	Column	m3	1800.00	39.08	70349.18
1.03	Beam	m3	1800.00	77.35	139230.00
1.04	Slab	m2	400.00	1296.48	518592.00
	Total summary				**869354.18**
	2. Reinforcement bar				
2.01	a) F 6mm	Kg	25.00	459.54	11488.50
2.02	b) F 8mm	Kg	25.00	3025.94	75648.62
2.03	c) F 10mm	Kg	25.00	676.73	16918.14
2.04	d) F 12mm	Kg	25.00	1751.14	43778.40
2.05	e) F 14mm	Kg	25.00	5757.21	143930.24
2.06	f) F 16mm	Kg	25.00	6963.71	174092.65
2.07	g) F 20mm	Kg	25.00	230.91	5772.78
2.08	g) F 24mm	Kg	25.00	4744.93	118623.25
	Total summary				**590252.58**
	Grand total				**1459606.75**

Table 4.7 Summary of cost output 8m span for ribbed structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m3	1800.00	98.56	177404.18
1.02	Column	m3	1800.00	46.80	84236.85
1.03	Beam	m3	1800.00	82.95	149301.36
1.04	Slab	m2	400.00	1478.88	591552.00
	Total summary				**1002494.39**
	2. Reinforcement bar				
2.01	a) F 6mm	Kg	25.00	532.80	13320.00
2.02	b) F 8mm	Kg	25.00	4804.06	120101.53
2.03	c) F 10mm	Kg	25.00	444.24	11106.00
2.04	d) F 12mm	Kg	25.00	2094.35	52358.70
2.05	e) F 14mm	Kg	25.00	6218.61	155465.31
2.06	f) F 16mm	Kg	25.00	8052.27	201306.71
2.07	g) F 20mm	Kg	25.00	266.44	6660.90
2.08	g) F 24mm	Kg	25.00	5434.70	135867.38
	Total summary				**696186.52**
	Grand total				**1698680.91**

Table 4.6 Summary of cost output 4m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	19.39	34906.50
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	36.25	65251.44
1.04	Slab	m^2	600.00	446.88	268128.00
	Total summary				**409190.49**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	1877.74	46943.58
2.03	c) Φ 10mm	Kg	25.00	1747.33	43683.29
2.04	d) Φ 12mm	Kg	25.00	2270.94	56773.39
2.05	e) Φ 14mm	Kg	25.00	1327.24	33181.01
2.06	f) Φ 16mm	Kg	25.00	528.97	13224.13
2.07	g) Φ 20mm	Kg	25.00	523.00	13075.10
	Total summary				**206880.49**
	Grand total				**616070.98**

Table 4.7 Summary of cost output 4.5m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	19.39	34906.50
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	37.89	68206.32
1.04	Slab	m^2	600.00	505.68	303408.00
	Total summary				**447425.37**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	1940.03	48500.67
2.03	c) Φ 10mm	Kg	25.00	389.45	9736.26
2.04	d) Φ 12mm	Kg	25.00	4041.06	101026.43
2.05	e) Φ 14mm	Kg	25.00	1638.20	40954.88
2.06	f) Φ 16mm	Kg	25.00	159.48	3986.98
2.07	g) Φ 20mm	Kg	25.00	601.95	15048.70
	Total summary				**219253.91**
	Grand total				**666679.28**

Table 4.8 Summary of cost output 5m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	21.35	38422.80
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	39.94	71899.92
1.04	Slab	m^2	600.00	564.48	338688.00
	Total summary				**489915.27**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	2100.64	52516.04
2.03	c) Φ 10mm	Kg	25.00	754.33	18858.30
2.04	d) Φ 12mm	Kg	25.00	4081.75	102043.63
2.05	e) Φ 14mm	Kg	25.00	1502.79	37569.68
2.06	f) Φ 16mm	Kg	25.00	496.28	12406.99
2.07	g) Φ 20mm	Kg	25.00	0.00	0.00
2.08	g) Φ 24mm	Kg	25.00	677.34	16933.50
	Total summary				**223394.64**
	Grand total				**713309.91**

Table 4.9 Summary of cost output 5.5m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	21.34	38412.00
1.02	Column	m^3	1800.00	22.72	40904.55
1.03	Beam	m^3	1800.00	44.18	79524.72
1.04	Slab	m^2	600.00	686.88	412128.00
	Total summary				**570969.27**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	2169.68	54241.99
2.03	c) Φ 10mm	Kg	25.00	823.07	20576.64
2.04	d) Φ 12mm	Kg	25.00	4507.54	112688.53
2.05	e) Φ 14mm	Kg	25.00	1244.79	31119.66
2.06	f) Φ 16mm	Kg	25.00	953.48	23836.98
2.07	g) Φ 20mm	Kg	25.00	0.00	0.00
2.08	g) Φ 24mm	Kg	25.00	846.68	21166.88
	Total summary				**242463.80**
	Grand total				**813433.07**

Table 4.10 Summary of cost output 6m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	24.26	43666.88
1.02	Column	m^3	1800.00	23.52	42342.30
1.03	Beam	m^3	1800.00	49.90	89824.32
1.04	Slab	m^2	600.00	821.28	492768.00
	Total summary				**668601.50**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	2223.38	55584.60
2.03	c) Φ 10mm	Kg	25.00	883.22	22080.58
2.04	d) Φ 12mm	Kg	25.00	4965.84	124145.95
2.05	e) Φ 14mm	Kg	25.00	1562.03	39050.70
2.06	f) Φ 16mm	Kg	25.00	598.91	14972.87
2.07	g) Φ 20mm	Kg	25.00	701.61	17540.37
2.08	g) Φ 24mm	Kg	25.00	0.00	0.00
	Total summary				**273375.07**
	Grand total				**941976.56**

Table 4.11 Summary of cost output 6.5m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	35.84	64505.48
1.02	Column	m^3	1800.00	24.68	44432.55
1.03	Beam	m^3	1800.00	58.53	105351.12
1.04	Slab	m^2	600.00	922.32	553392.00
	Total summary				**767681.15**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	2330.91	58272.77
2.03	c) Φ 10mm	Kg	25.00	671.97	16799.37
2.04	d) Φ 12mm	Kg	25.00	5696.66	142416.55
2.05	e) Φ 14mm	Kg	25.00	1379.23	34480.68
2.06	f) Φ 16mm	Kg	25.00	1038.35	25958.76
2.07	g) Φ 20mm	Kg	25.00	42.43	1060.81
2.08	g) Φ 24mm	Kg	25.00	2041.61	51040.13
	Total summary				**278988.94**
	Grand total				**1046670.08**

Table 4.12 Summary of cost output 7m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m^3	1800.00	47.78	86011.20
1.02	Column	m^3	1800.00	25.78	46398.15
1.03	Beam	m^3	1800.00	62.13	111825.36
1.04	Slab	m^2	600.00	1101.48	660888.00
	Total summary				**905122.71**
	2. Reinforcement bar				
2.01	a) Φ 6mm	Kg	25.00	0.00	0.00
2.02	b) Φ 8mm	Kg	25.00	2374.83	59370.67
2.03	c) Φ 10mm	Kg	25.00	717.57	17939.28
2.04	d) Φ 12mm	Kg	25.00	5839.97	145999.19
2.05	e) Φ 14mm	Kg	25.00	1442.58	36064.47
2.06	f) Φ 16mm	Kg	25.00	1068.04	26700.89
2.07	g) Φ 20mm	Kg	25.00	45.39	1134.82
2.08	g) Φ 24mm	Kg	25.00	2421.10	60527.50
	Total summary				**287209.32**
	Grand total				**1192332.03**

Table 4.12 Summary of cost output 7.5m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m3	1800.00	57.52	103538.25
1.02	Column	m3	1800.00	31.81	57254.4
1.03	Beam	m3	1800.00	66.35	119422.8
1.04	Slab	m2	600.00	1296.48	777888
	Total summary				**1058103.45**
	2. Reinforcement bar				
2.01	a) F 6mm	Kg	25.00	0.00	0
2.02	b) F 8mm	Kg	25.00	2267.04	56675.9825
2.03	c) F 10mm	Kg	25.00	639.21	15980.3
2.04	d) F 12mm	Kg	25.00	5982.49	149562.288
2.05	e) F 14mm	Kg	25.00	1668.42	41710.5
2.06	f) F 16mm	Kg	25.00	1228.15	30703.655
2.07	g) F 20mm	Kg	25.00	325.64	8141.1
2.08	g) F 24mm	Kg	25.00	2511.27	62781.75
	Total summary				**365555.5755**
	Grand total				**1423659.026**

Table 4.12 Summary of cost output 8m span for composite slab structure

Item No	Description of work	unit	Rate	Quantity	Amount
	A. SUB STRUCTURE				
	1. CONCRETE				
1.01	Footing	m3	1800.00	67.71	121881.375
1.02	Column	m3	1800.00	38.68	69632.55
1.03	Beam	m3	1800.00	80.75	145355.76
1.04	Slab	m2	600.00	1478.88	887328
	Total summary				**1224197.685**
	2. Reinforcement bar				
2.01	a) F 6mm	Kg	25.00	0.00	0
2.02	b) F 8mm	Kg	25.00	2267.04	56675.9825
2.03	c) F 10mm	Kg	25.00	639.21	15980.3
2.04	d) F 12mm	Kg	25.00	5982.49	149562.288
2.05	e) F 14mm	Kg	25.00	1668.42	41710.5
2.06	f) F 16mm	Kg	25.00	1228.15	30703.655
2.07	g) F 20mm	Kg	25.00	325.64	8141.1
2.08	g) F 24mm	Kg	25.00	2511.27	62781.75
	Total summary				**365555.5755**
	Grand total				**1589753.261**

Table 4.13 The total summery of cost output

Item No	Span Length(mm)	Total cost for ribbed with time value of money	Total cost for composite
1	4	535338.70	616070.98
2	4.5	586124.82	666679.28
3	5	631400.03	713309.91
4	5.5	733466.89	813433.07
5	6	819542.32	941976.56
6	6.50	961936.87	1046670.08
7	7	1165462.51	1192332.03
8	7.5	1461168.45	1423659.03
9	8	1700498.40	1589753.26

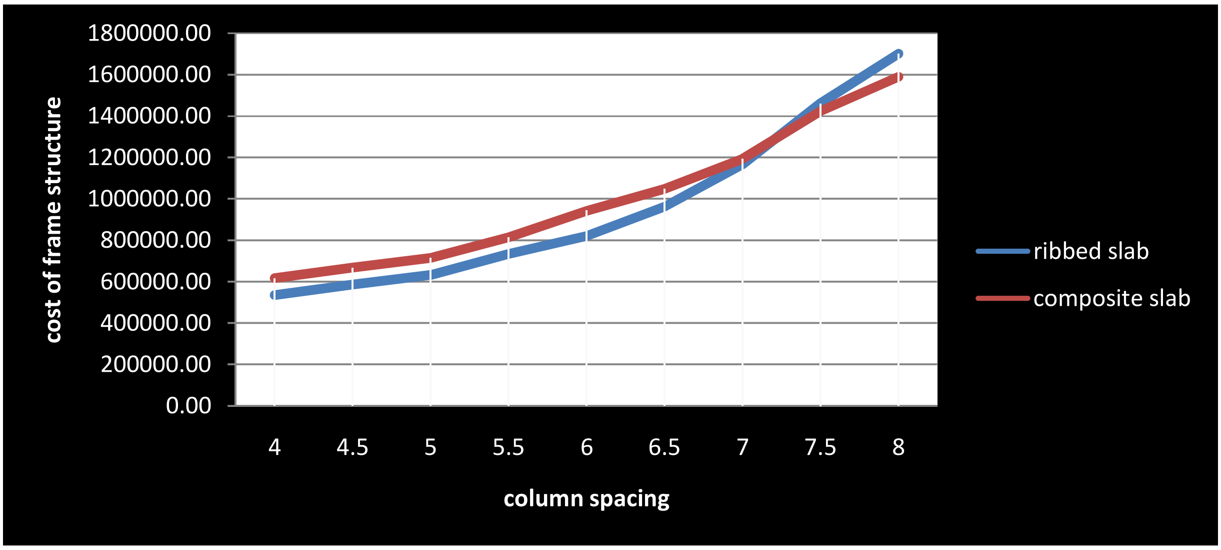


Fig 4.1 span and cost comparison of ribbed and composite slab

4.2 Discussions

Figure 4.1.shows the effect of column spacing on the cost of composite and ribbed slab. There was considered nine building structure from composite and ribbed slab during analysis, that was L=4m, L=4.5m, L=5m, L=5.5m, L=6m L=6.5m, L=7m, L=7.5m and L=8m length however shown in Fig.4.1, the cost of ribbed slab increasing at increasing rate after 5m column spacing but composite slab cost is increase at decreasing rate after 5.5m of column spacing , the cost of ribbed slab become greater after 7m column spacing.

CHAPTER FIVE

5. Conclusion and Recommendation

5.1 Conclusion

A study on the effect of cost on structure of Building by change the column spacing was presented and discussed. In composite slab frame the cost increase with at decreasing rate as compeer ribbed slab. From the result, the following conclusions are drawn.

- The weight of composite slab is less than ribbed one but within these building height and span length the effect of weight on cost is less because of most of structural members within minimal limit requirement. In our country (Ethiopia) the cost of steel sheet is very high so within this span using ribbed slab is economical with that of composite but the span length greater than 7m composite slab is economical.
- The result of the research showed composite slab economical for long span. In case of composite slab frame has a property of concrete and steel this make the frame light and strong so the cost of the building decrease while height and span increase.

5.2 Recommendation

This study is made only on the theoretical or analytical bases, further studies can be done in the laboratory and also a comprehensive study of cost saving in buildings by considering all factors, such as cost factor of height of the building and for large span case.

References

1. Johnson, R. (1994). *Composite Structures of Steel and Concrete* (Vol. 1). London: Blackwell Scientific Publishers.

2. Shweta A. Wagh D. U. (2014). *Comparative Study of R.C.C and Steel Concrete Composite*. Shweta A. Wagh et al Int. Journal of Engineering Research and Applications , 4 (4), 369-376.

3. Yuen, L. a. (2001). *A Resource Book for Structural Steel Design and Construction*. Singapore : Singapore Structural Steel Society and Building And Construction Authority,

4. Ethiopian Building Code Standard:EBCS-8(1995): *design of structures for earthquake resistanc*e. Addis Ababa: Ministry of Works and Urban Development.

5. Ethiopian Builing Code Standard:EBCS-1 (1995). *Basis of design and Actions on structures* . Addis Ababa: Ministry of Works and Urbun Development.

6. Ethiopian Building Code Standard :EBCS-2(1995): *Structural use of concrete* . Addis Ababa: Ministry of Works and Urban Development

7. Ethiopian Building Code Standard:EBCS-4(1995):*Design of Composite Steel and Concrete structures*. Addis Ababa: Ministry of Works and Urban Development.

8. James k. Wight and James G. *Macgregor. Reinforced concrete 6E*: Department of Civil and Environmental Engineering, University of Michigan and Alberta.

9. Matheas Kebede M.S.C *Analysis Design and Cost Effectiveness of Precast Beam-Slab System* school of Civil and Environmental Engineering, Addis Ababa Institute of Technology, AAU

10. Merid Belay M.S.C Use *of composite concrete slab system using hollow block and precast slab and beam member* school of Civil and Environmental Engineering, Addis Ababa Institute of Technology, AAU

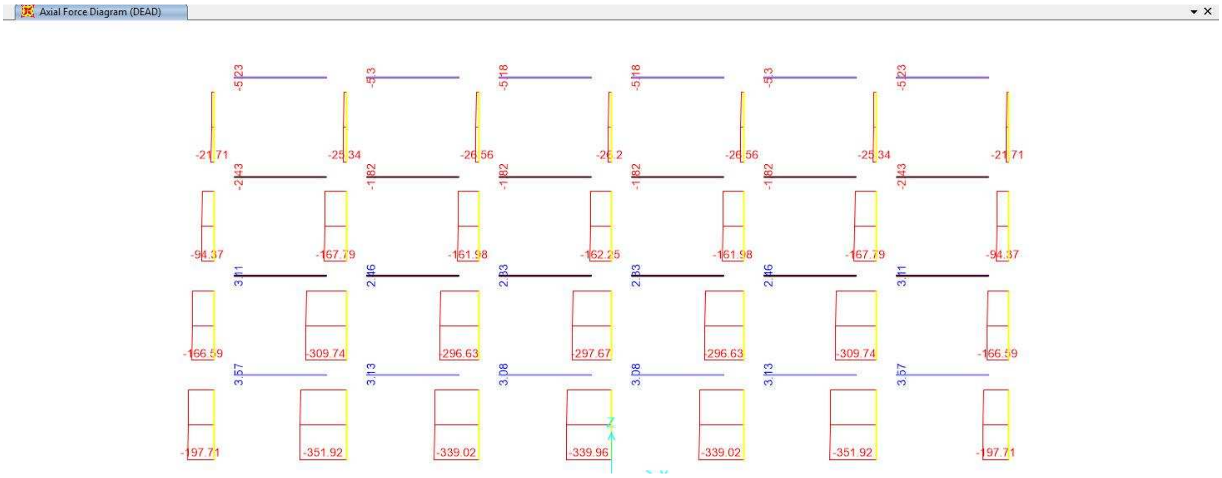
11. Tedia, A. (2014). Cost, *Analysis and Design of Steel-Concrete Composite*. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , 11 (1), 54-59.

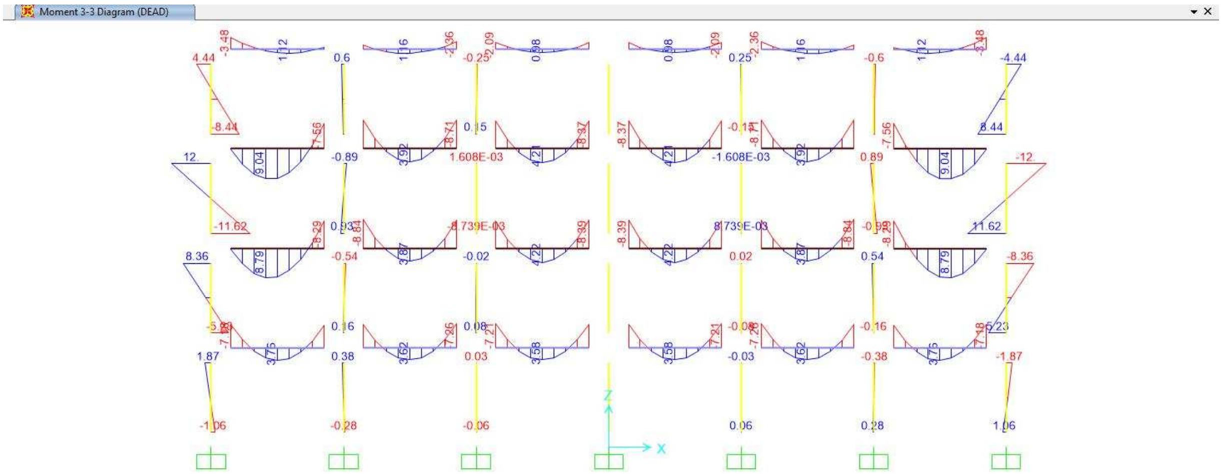
12. Shashikala. Koppad, D. S. (2013). *Comparative Study of RCC and Composite*. International Journal of Engineering and Innovative Technology (IJEIT) , 3 (5), 341-344.

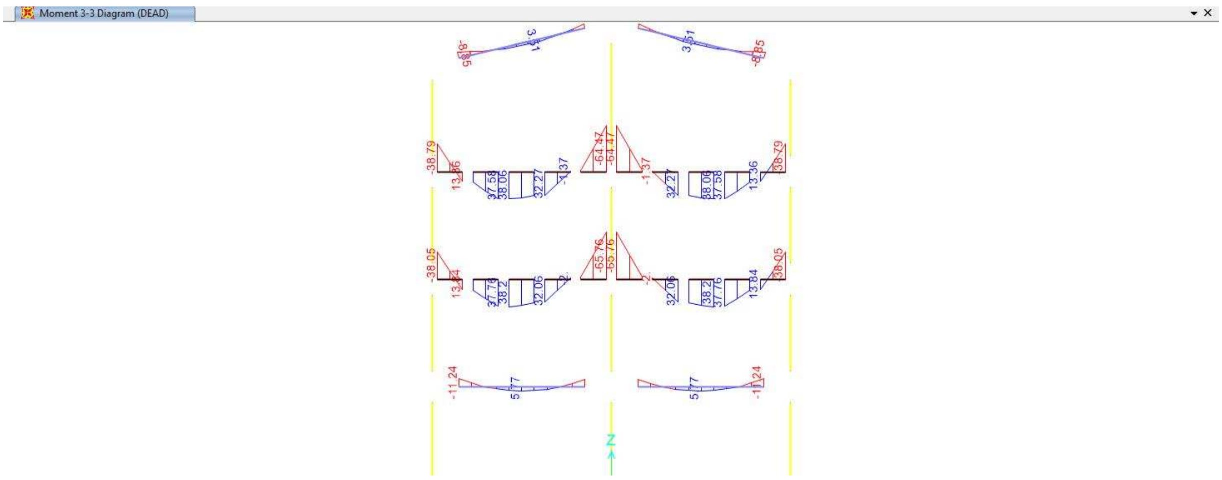
13. Hanoi, V. (2007). Modern *design, construction and maintenance of composite steel-concrete structures*: Australian experiences. International Conference on Modern Design, 42-48.

Annexes

1 SAP analysis data


Axial Force Diagram (DEAD)


Moment 3-3 Diagram (DEAD)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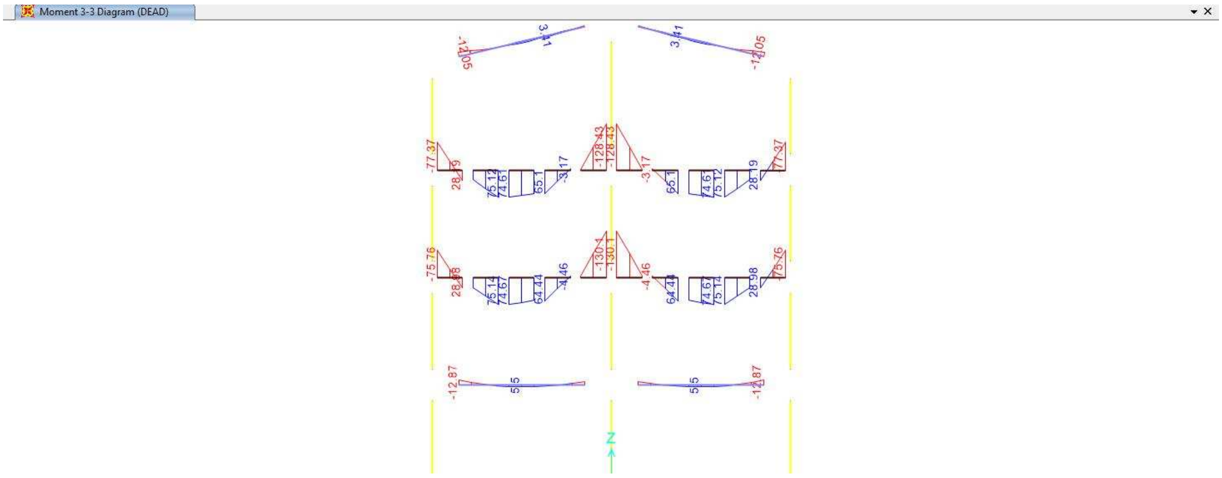
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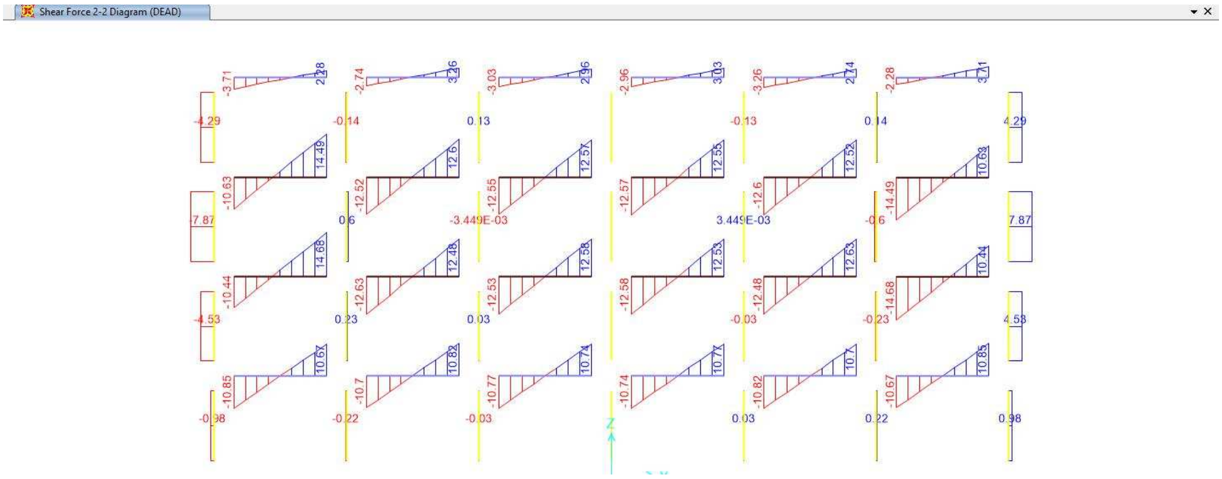
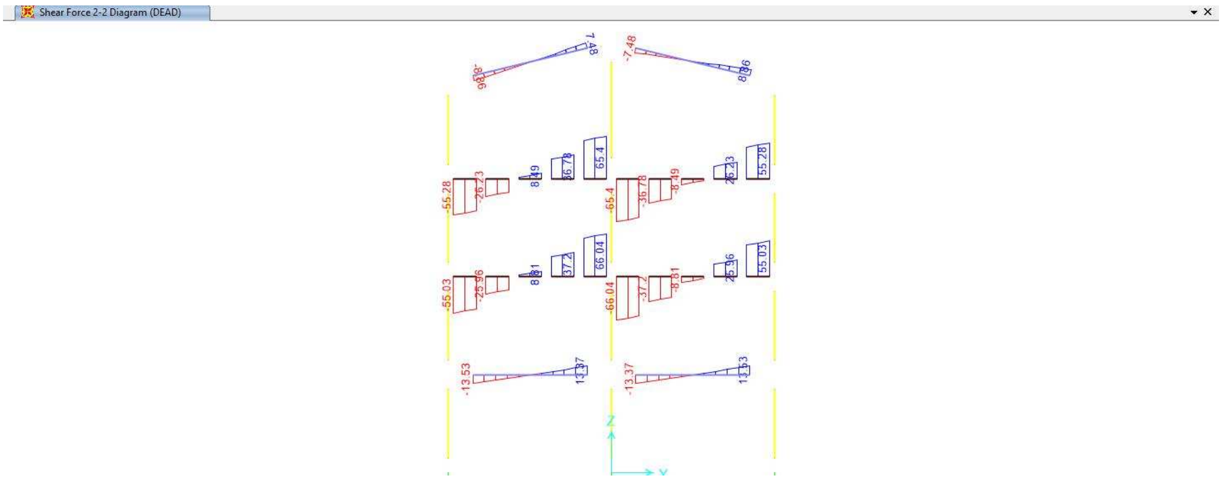

Shear Force 2-2 Diagram (DEAD)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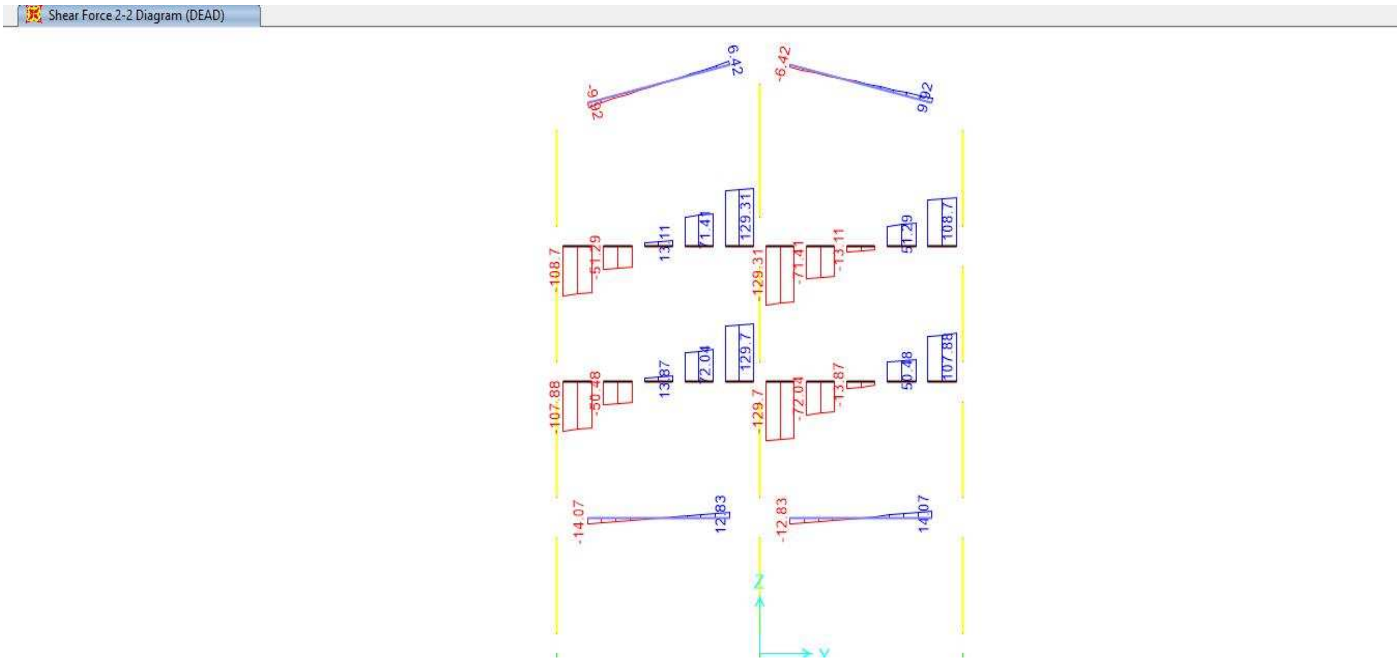

2 **Design template for composite slab, ribbed slab and footing**

Footing Group	1		
Ultimate load, P_s (Kn)	460.00		
Mx (Kn-m)	0.46		
My (Kn-m)	2.49		
Column width, a (m)	0.30		
Foundation depth, f_d (m)	2.50		
Allowable bearing capacity for factored loads, s (Kpa)	330		
Footing Dimension, L * b (m)	1.30	1.30	
Depth, D (m)	0.45		1.5 - 2 times column size 1.5*0.3

Footing Area, A_f (m^2)	1.69			
Effective depth, d (m)	D - 0.035- bar dia.	0.403		
Own Weight of Footing, Wc (Kn)	A_f*D*g_c	19		
Unit weight of soil, g_s (Kn/m^3)	15.00			
Soil Weight , Ws(Kn)	A_f*($f_{d\ -}$ D)*g_s	52		
Total load on footing, P_T (Kn)	Ps+Wc+Ws	531		
Checking Bearing pressure (Kpa)		314		P_T/A
Max. soil pressure, Qmax. (Kpa)		280		p_s/A(1+(6*Mx)/(b*Ps)+ (6*My)/(L*P < Qult
Min. Soil pressure, Qmin. (Kpa)		264		p_s/A(1-(6*Mx)/b-(6*My)/L) >0.0
Tensile strength of conc., f_{ctd} (Mpa)		1.04		0.35*(f_c)^0.5/1.5
Allowable punching resistance of concrete, Vup(Kn/m2)		307		0.25*fctd*(1+50P)*(1.6-d) *10^3
Allowable wide beam shear resistance of concrete, v_{ud} (Kn/m2)		307		0.25*fctd*(1+50P)*(1.6-d)*10^3
Punching Shear, Vp (kn)		305		P_{s-}((a+d)^2*Qact)
Punching Shear Stress, Vup (Kpa)		269		V_p/(4(a+d)*d)
Wide beam Shear, Vw_p (Kn/m)		26		(Ps/Af)*(L/2-d-a/2)
Wide beam Shear stress (Kn/m^2)		66		Vwp/(b*d)
Max Design Moment, Md(Kn-m)		35		0.25*(Qmin + 3* Qmax)*((L-a)/2)^2)*0.5
K		213		(Md/d^2)
rho (%)		0.049	500	(Fyd-SQRT(Fyd^2 - (4 *131.857*E29)/1000))*100/(2*3131.85
Diameter of Steel, (mm)		12	435	
Single Area, a_s (mm^2)		113.14		22/7*dia.^2/4
Area of Steel required, A_{sd} (mm^2)		221		p*b*d
Minimum Reinforcement, $A_{s,min.}$(mm^2)		621		(0.6/f_{yd})*b*d
Provided Area of steel, A_s (mm^2)		621		MAX(required,designed)
Spacing, S (mm)		182		a_s*b/(A_s)